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ACCOUNT
OF A
NEW HYGROMETER,
TOGETHER WITH
Observations on Ice-Houses,
DEDUCED FROM
HYGROMETRICAL CONSIDERATIONS,

BY

GEORGE CUMMING, M. D.

> ALL THE RIVERS RUN INTO THE SEA; YET THE SEA IS NOT FULL; UNTO THE PLACE FROM WHENCE THE RIVERS COME, THITHER THEY RETURN AGAIN.—*Ecclesiastes, Chap. I.*

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THE distinguished merits of Mr. Dalton as a Philosopher must be well known to every one conversant with the progress of British Chemistry and Meteorology; and, in common with others, I have ever considered the following experiment for determining the varying force of *Aqueous Vapour* in the atmosphere, as a genuine specimen of cautious, or inductive philosophy. "In order to find the force of the aqueous atmosphere," (says Mr. Dalton in his 'Essay upon the force of steam or vapour from water and other liquids of different temperatures,' 5th vol. page 581, of the 'Memoirs of the Literary and Philosophical Society of Manchester,') "I usually take a tall cylindrical glass jar, dry on the outside, and fill it with cold spring water fresh from the well; if dew be immediately formed on the outside, I pour the water out, let it stand awhile to increase in heat, dry the outside of the glass well with a linen cloth, and then pour the water in again; this operation is to be continued till dew ceases to be formed, and then the temperature of the water must be observed; and opposite to it will be found the force of vapour in the atmosphere. This must be done in the open air, or at a window; because the air within is generally more humid than that without. Spring water is generally about 50°, and will mostly answer the purpose the three hottest months in the year; in other seasons an artifiical cold mixture is required. The accuracy of the result obtained this way I think scarcely needs to be insisted upon. Glass, and all other hard smooth substances, I have tried, when cooled to a degree below what the surrounding Aqueous Vapour can support, cause it to be condensed on their surfaces into water. The degree of cold is usually from 1 to 10 below the mean heat of the 24 hours; in summer I have often observed the point as high as 58° or 59°, corresponding to half an inch of mercury in force, and once or twice have seen at 62°; in changeable and windy weather it is liable to considerable fluctuation." But the great objection to this mode of experimenting, it may be observed, consists in the length of time required to verify an observation, to say nothing of the trouble of employing "an artificial cold mixture" for the greatest part of the year. Hence the satisfaction with which the labours of Mr. Daniel, as well as those of Mr. Jones, to produce a Hygrometer that should readily mark the "comparative degrees of moisture and dryness in the atmosphere, and by exhibiting them in degrees of the Thermometer, refer them to a known standard of comparison, and speak in a language which every body understands," have been received by Meteorologists: and it is but generous to remark, that Mr. Daniel (making every allowance for the imperfections of his Hygrometer, real or supposed) has not been treated, by a certain body of men, with the courtesy which the great zeal, industry, and science, evinced in his "Meteorological Essays," so well entitled him.

It, however, has been well observed that "among the many erroneous views which people take of the origin of the sciences, no one appears more common than that of supposing that they have all been originally undertaken and pursued with some particular aim to public or individual utility; as if the investigation of nature was not valuable; nor natural phenomena capable of exciting us to the pursuit of their causes, on account of the pleasure they produced in engaging the energies of our different intellectual faculties, independently of any further purpose to which they might be made subservient" That Mr. Daniel has had his reward in the ennobling exercise of his mental powers is hardly to be doubted, and therefore the unmerited neglect of the Royal Society, may the more easily be endured; and it reflects infinite credit upon him for "the careful avoidance of all allusion," in the second edition of his Essays, "to subjects which, however intense the personal interest which they excite at the moment of discussion, can be but of ephemeral importance."

Of the merits of the rival Hygrometers of Messrs. Daniel and Jones, it would ill become the author to speak, as an accident upon the road, after waiting with impatience for months for the arrival of Mr Jones's instrument, deprived him of the power of instituting a set of comparative experiments; but should Mr. Daniel's observations upon Mr. Jones's Hygrometer, as published in No. xlii. of the Journal of Science and the Arts, prove correct, the accident above alluded to, may fairly be considered the efficient cause of the production of the following **IMPROVED INSTRUMENT.**

The Hygrometer in question is extremely simple, and is intimately founded upon the principle pursued by Mr. Dalton in his mode of interrogating nature. But instead of using "a tall cylindrical glass jar, with water fresh from the well, and artificial cold mixtures," I employ the accelerated evaporation of Æther, or of a less costly article, Rectified Spirit of Wine, by directing a current of air through a thin glass or metallic tube, of convenient size, containing a delicate Thermometer enveloped in sponge or other porous substance: when it will be obvious that, by the affusion of a little Æther upon the porous body surrounding the bulb of the Thermometer, almost any degree of artificial cold may be produced by simply mounting the PRERARED TUBE upon the nozzle of a small pair of bellows, or other pneumatic contrivance, thus rendering, by the abstraction of heat from the tube employed, the condensation of Aqueous Vapour upon its exterior surface, a matter of ease, certainty, and expedition, while the comparison of the temperature of the air, at the commencement of the experiment, with the mean of the indications of the Thermometer at the appearance and at the evanescence of the Dew, opposite to the bulb of the Thermometer, will give, with relative accuracy, the measure of the force of Vapour in the atmosphere.

But, in general terms, it is not desirable to depress the instrument many degrees below that at which dew becomes visible, on account of the increased length of time requisite to complete an observation. When the Hygrometer is consulted with a view of predicting the greater or less probability of rain, or other atmospheric changes, two things (Mr. Daniel observes) are to be principally attended to—"the difference between the constituent temperature of the vapour, and the temperature of the air, and the variation of the dew-point. In general, the chance of rain or other precipitation of moisture from the atmosphere, may be regarded as in inverse proportion to the difference between the" Thermometical indications: " but in making this estimate, regard must be had to the time of day at which the observation is made. In settled weather the dryness of the air increases with the diurnal heat, and diminishes with its decline; for the constituent temperature of the vapour remains nearly stationary But to render the observation most completely prospective, regard must be had at the same time to the movement of the dew-point. As the elasticity of the vapour increases or declines, so does the probability of the formation and continuation of rain. An increasing difference, therefore, between the temperature of the air, and the temperature of the point of condensation, accompanied by a fall of the latter, is a sure prognostication of fine weather; while diminished heat, and a rising dew-point, infallibly portend a rainy season."

The following extracts from Mr. Daniel's Table, shewing the force, weight, and expansion of Aqueous Vapour, at different temperatures, will tend to place the importance of the study of Hygrometry to the Physician, Horticulturist, and Man of Science, in a favourable point of view:

Temperature.	*Force.*	*Weight of a Cubic Foot.*	*Expansion.*
30	0.200	2.361	.9959
35	0.240	2.805	1 0062
40	0 280	3.239	1 0166
45	0 340	3 893	1 0270
50	0 400	4 535	1.0375
55	0.476	5.342	1 0479
60	0 560	6 222	1 0583
65	0 657	7 230	1 0687
70	0.770	8 392	1 0791

Assuming, therefore, that changes in the Aqueous Atmosphere[*] must exercise an important influence upon the general economy of nature: Who is prepared to say that, as a healthy man consumes 130 cubic feet of air daily, the manageable relations of heat and moisture, as indicated by the Hygrometer, might not be beneficially applied to the treatment of disease, as well in private life as in public institutions, or that, were an increased share of attention paid to the study of atmospheric phenomena, the causes, or " constitution of the air," regulating the rise, type, and progress of disease in general, (a subject deeply involved in obscurity) might not happily be developed?

[*] *On the 17th July,* 1827, *the dew-point, at ten o'clock a. m. was* 56°, *the temperature of the Atmosphere* 72°; *so that the dryness of the air, under the above conditions, may be conveniently expressed as*---16°, *at noon it was* 14°, *at six o'clock p m it had advanced to* 10°, *and was followed by considerable rain in the night. On the* 19th, *the dew-point, at noon, was* 61°, *air* 65°, *difference* 4°, *immediately followed by rain. To-day (26th) the dew point is* 58°, *attended with much rain, the temperature of the air being* 62°. *But the author has strongly to recommend Mr. Daniel's Essays to the attention of the Meteorological Student; and to adopt his language, (in speaking of his invention) I have only to hope that the NEW HYGROMETER "may be judged upon its own merits alone; and if it shall be found to be liable to no errors of construction, and no deterioration, from use or age; if its indications shall prove to be infallible, and strictly comparable, under all circumstances; and if, moreover, it be easy to observe, and its observations applicable without the trouble and uncertainty of* formulaic *calculations, I shall hope that, for the good of science, it may be generally adopted."*

DESCRIPTION.

FIGURE 1 represents THE PREPARED HYGROMETER TUBE. A. Glass Tube from eight to twelve inches long BB Brass or other mountings. C. Thermometer enveloped in sponge or other light porous substance and covered with black silk, in order to render the dew more visible when tubes of coloured glass cannot be procured.

FIGURE 2 represents a COMPLETE HYGROMETER as mounted upon the nozzle of a pair of bellows.

FIGURE 3 is a STANDARD INSTRUMENT, mounted upon a bell-glass immersed in a vessel containing water, so as to act, upon turning a stop-lock, as a Gasometer. A is a highly polished thin metallic tube or case, with lateral opening for reading off the degrees of the Thermometer, in a glass tube, (as in the former instruments) but shortened so far as to allow the sponge or other body surrounding the bulb of the Thermometer B, to come in contact with the metallic case, and thereby to make the indications of the same correspond as near as possible with the constituent temperature of the dew upon its exterior surface.

FIGURE 4 is a PORTABLE HYGROMETER with metallic tube or case, as in Figure 3, mounted upon an air-syringe or air-pump. In general terms, polished metallic tubes will be found to possess decided advantages over those of glass, especially when used at night, as with them the verification of the dew-point becomes as easy at night as at mid-day.

☞ *Since the Lithographic Drawings were completed, the following improvement, in fitting up the Instrument above described, has been made, namely the surrounding of the Hygrometer with a glass cover, (of double the diameter of the Hygrometer tube) with openings in the metallic mountings for allowing of the regulated play of the atmosphere: So that by thus protecting the Artificial Dew the Meteorologist will be enabled to make his observations, with accuracy, in the open air, and under every varying circumstance of the weather.*

NEW HYGROMETER.

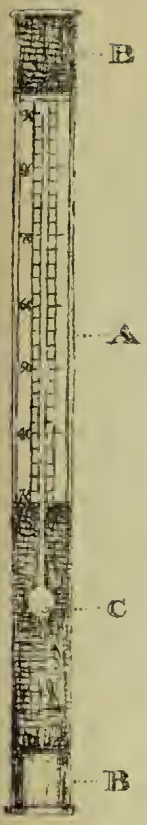


Fig. 2.

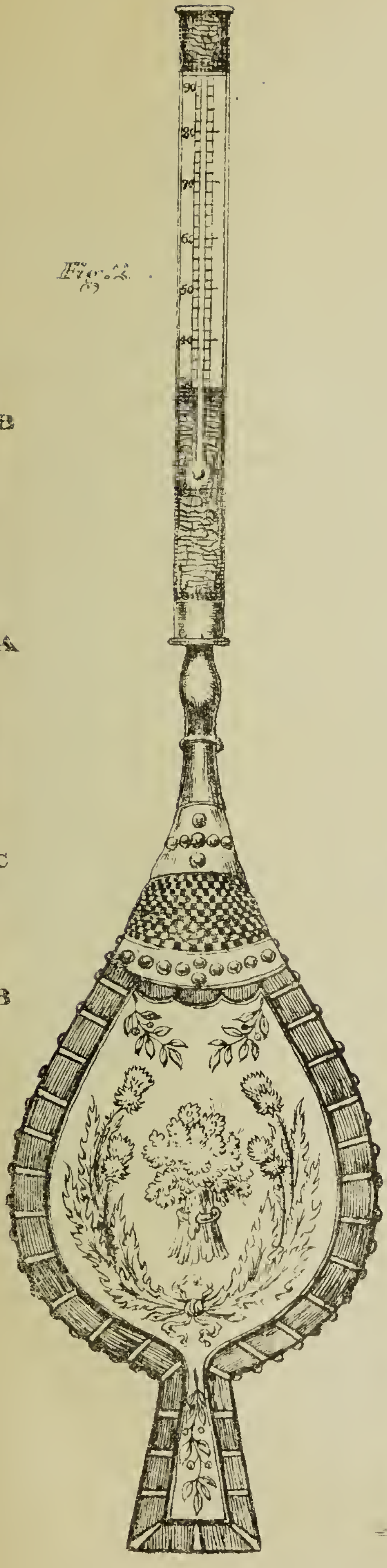


Fig. 3.

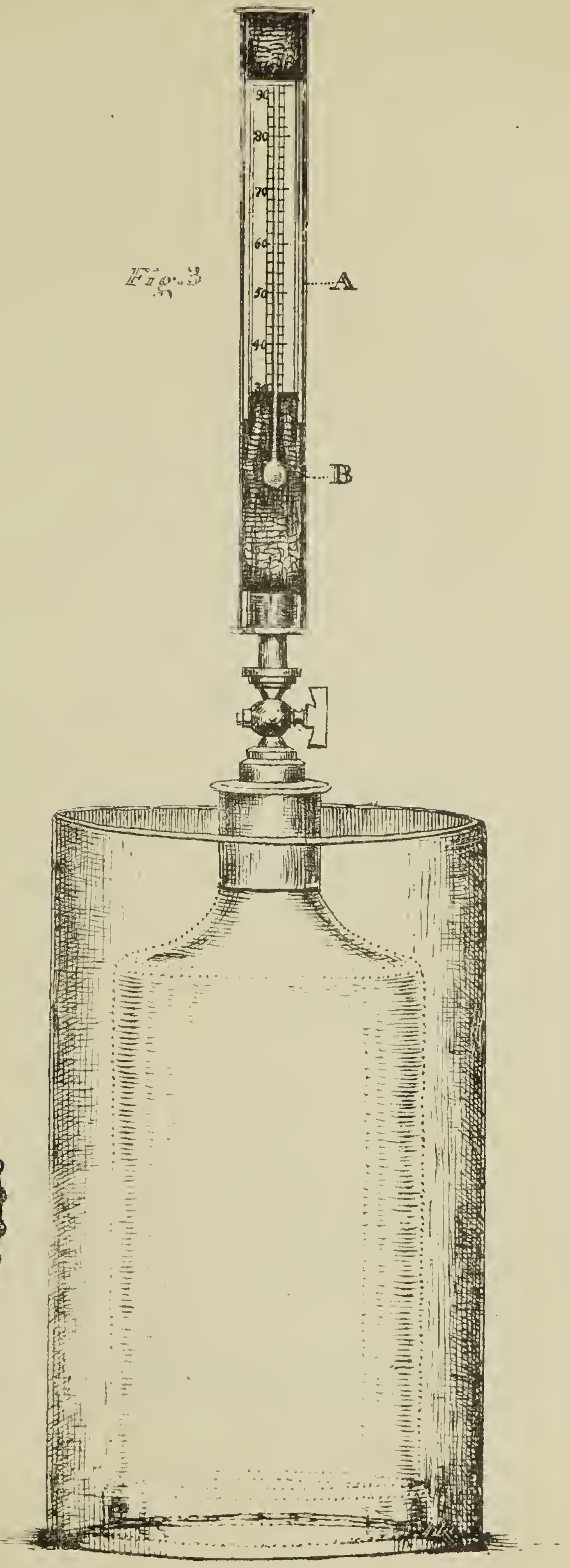
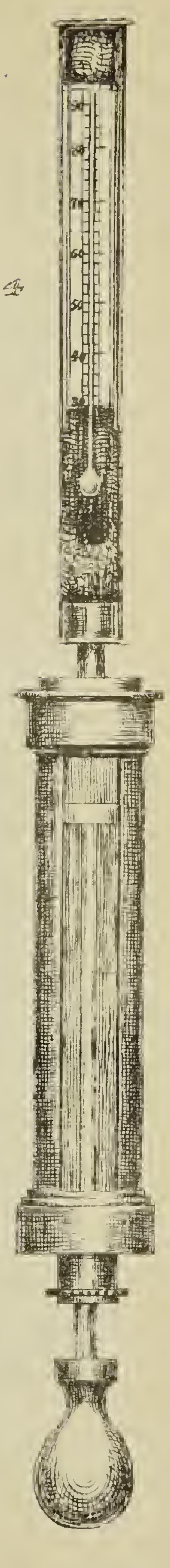


Fig. 4.



JN. MUSGROVE. CHESTER 1827.

OBSERVATIONS ON ICE-HOUSES.

THE number of decayed and imperfect Ice-Houses to be met with in different parts of the country, sufficiently attest the empirical nature of the principles upon which they have hitherto been constructed, few practical men being able to assign a reason why a given plan should afford satisfaction in one place, and prove the source of endless vexation and disappointment in another. Indeed, the whole of our floating knowledge in this interesting department of art may be comprised in a few words, namely a Pit in the Earth with proper Doors to protect the Ice from the influence of a heated atmosphere, and a Drain (furnished with an Air-Trap) to keep the House "free from moisture."

But the merest reflection would tell us, that as the temperature of the Earth at equal depths is the same under the same parallel of latitude, we must, in order to account for the comparative failure of the same plan under apparently similar circumstances, look to another physical agent for a solution of the problem of the mysterious liquefaction of Ice in particular Houses It is generally allowed that the temperature of Spring Water may be taken as a standard for the mean temperature of the climate (reference being made to latitude and local elevation above the level of the sea), as "the heat thus obtained is only the mean result of all the various impressions which the surface of the Earth receives from the Sun and the Atmosphere." Taking therefore Spring Water at 48° Fahr. it will yield a Vapour of considerable elastic force, a fact that must be familiar to every one conversant with the appearance of nature in a calm frosty morning: --hence the theory of the explanation which I would offer for the rapid disappearance of Ice in the majority of existing Houses. If the sub-soil should happen to be stiff Clay or Chalk, substances impervious to Vapour, the common Ice-House will give average satisfaction; if, on the contrary, the sub-soil should prove permeable to Water, the Vapour arising from the same will press in through every chink and crevice of the "steened Walls," i. e. Walls without Mortar, with a given force, thus resolving the contained Ice into Water with destructive energy, by a species of inward distillation, and completely setting at defiance the apparatus of Double Doors and Drains with Air-Traps, how carefully soever constructed.

Having often had occasion to regret the limited and precarious supply of Ice (the cheapest and best of luxuries) that even the most wealthy are able to command, my attention was first forcibly called to the investigation of the defective structure of Ice-Houses, when paying a morning visit last Summer, to a Gentleman whom I found busily engaged in fitting up an Ice House in a bed of Sand, but resting immediately upon Gravel, permeated at the depth of two feet by fine Spring Water. My decided opinion was, from the "Hygrometrical reasons" assigned, that it would not answer, however dry the Sand was, and even capable of transmitting, without the help of a Drain, the Water formed from the melting Ice, as the cloud of Vapour from the Spring below would infallibly melt the fullest charge of which the House was capable in a short time; my advice, therefore, was to lay a concave floor of highly wrought Clay, two feet thick or so, upon the Sand, then to pass a Lead Pipe (for carrying off the Water as formed) through the same into the Spring, thus reducing a *Sand evaporating surface*, of probably 100 square feet, to the comparative insignificance of the diameter of the Pipe (say one inch) employed! It was further suggested, that it would be advisable to fill in, behind the Walls of the House, a foot or two of wrought Clay, to prevent the possible ingress of Vapour laterally. This being done, the structure would then, in my humble opinion, promise to prove relatively efficient.

Professor Beckman, in his History of Inventions, observes that the Ancients from the earliest ages were acquainted with the method of preserving Snow, for the purpose of cooling liquors in the Summer, but how the Repositories were constructed we are not expressly told --- "That the Snow was preserved in pits or trenches is asserted by many. When Alexander the Great besieged the City of Petra, he caused trenches to be dug and filled with Snow, which was covered with Oak branches, and which kept in that manner for a long time. Plutarch says that a covering of chaff and coarse cloth is sufficient; and at present a like method is pursued in Portugal. Where the Snow has been collected in a deep gulph, some Grass or green Sods, covered with dung from the Sheep-pens, is thrown over it; and under these it is so well preserved that the whole Summer through it is sent the distance of sixty Spanish miles to Lisbon. When the ancients therefore wished to have cooling liquors they either drank the melted Snow or put some of it in their Wine, or they placed jars filled with Wine in the Snow, and suffered it to cool there as long as they thought proper. It appears that in these trenches it could not remain long clean; on the contrary it was generally so full of chaff that the Snow-water was somewhat coloured with it and had a taste of it, and for this reason it was necessary to strain either it or the Wine that had been cooled by it That Ice also was preserved for the like purpose is probable from the testimony of various authors; but it appears not to have been used so much in warm countries as in the Northern. Even at present Snow is employed in Italy, Spain, and Portugal, but in Persia Ice. I have never any where found an account of Grecian or Roman Ice-Houses. By the writers on Agriculture they are not mentioned."

In the treatment of disease the application of cold both externally and internally is of unquestionable utility---in certain stages of fever the cold affusion has been employed with the happiest results, and cooling drink may be administered with advantage in a variety of disorders which assail the human frame It may not, therefore, be too much to hope that the enlightened Governors of our Public Hospitals will be induced to encourage the establishment of Ice Houses in aid of ordinary Medicine, a small fragment of Ice being sufficient in melting to chill a considerable body of Water. In the hopes, therefore, of promoting the advancement of the arts of life, I have ventured to propose a plan for an IMPROVED ICE HOUSE *above ground,* as it appears that the enemy chiefly to be guarded against is Aqueous Vapour, and not Atmospheric Air as is commonly supposed; Dry Air at 48° (mean temperature of the climate) being in comparison to Steam or Vapour at the same temperature a non conductor of Caloric. In the plan proposed it will be observed that the ingress of Vapour from the Earth is effectually prevented, and consequently the waste of Ice will be reduced to the lowest quantity due to the radiation of heat from the influence of the season.

On the 29th April, 1827, the maximum Solar Power, at the surface of the Earth, was observed to be 94°. Fahr and was dissipated by

The Wind	25
Evaporation	41
Radiation	28---94

Minimum temperature of the preceding night 38°---maximum of the air in the shade 66°.

On the 29th April, 1828, the maximum Solar Power was 32°, and was carried off by

The Wind	10
Evaporation	5
Radiation	17---32

Minimum of the preceding night 50°---maximum heat of the air in the shade 67°.

It therefore appears that the direct Solar Power may at all times be completely neutralized by the process of evaporation aided by the wind, by throwing Water by a Hand Pump or Garden Engine upon the Thatch and Matted sides of the House, as practised in India; and it further may be observed, that it would be an error to erect an Ice-House under the shelter of Trees; as the average temperature of the air in shady places is considerably higher than in open exposures, as is familiarly exemplified in the comparative absence of dew and hoar frost in confined situations.

As to the item of expence it may be taken for granted that an Ice-House upon the plan proposed may be realized for a less sum, (£30) than is commonly required to construct one of the same dimensions *under ground,* upon established, but as it appears to the writer, erroneous principles.

DESCRIPTION.

A. *Body of the Ice-House.*

B. *Strong Grating for supporting the Ice*

C. *Reservoir for Ice cold Water, the sensible heat or temperature of Ice not being changed by liquefaction. A Thermometer in pounded Ice will stand at* 32°, *and at the very same point in the Water resulting from its liquefaction.*

D. *Syphon eduction Lead Pipe, mounted with a Stop-Cock to regulate the accumulation of Ice Water as wanted. In Summer the waste of, as well as the demand for Ice, will naturally be greatest, and hence the importance of being able to apply the Water formed by the heat of the season to useful purposes.--Five pounds of Ice Water may fairly be reckoned equal in value in Summer to one pound of Ice, for if to a pound of Water at* 172° *we add a pound of Ice the temperature will not be the mean* (102°), *but much below it, viz.* 32°. *All the excess of Caloric in the hot Water has therefore become latent, and if from* 172° *we deduct* 32°, *the remainder* 140° *will shew the quantity of heat that enters into a pound of Ice during its liquefaction; that is, as much Coloric is absorbed by a pound of Ice, during its conversion into Water, as would raise a pound of Water from* 32° *to* 172°.

E. E E *Concentric Brick Walls with Air Cells, from eight to twelve inches wide, in order to prevent the impression of the Sun and of the Atmosphere as much as possible upon the contained Ice, dry Air being in comparison to solid bodies, Metals in particular, a non-conductor of Caloric.*

G. G. *Concave mass of highly wrought Clay, three feet deep, not less useful in forming a Reservoir for the Ice Water than in preventing the entrance of Vapour from the Earth.*

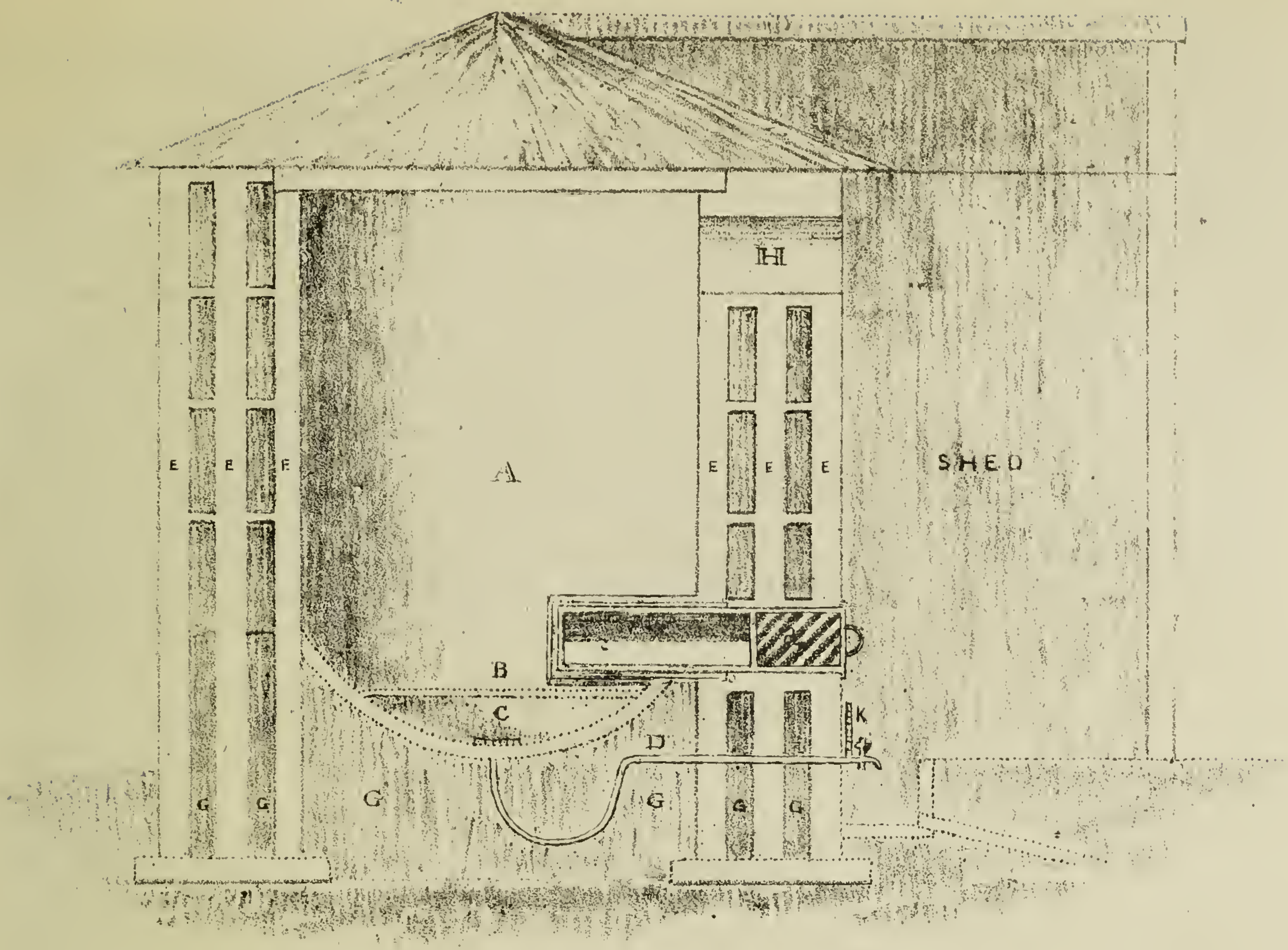
H H. *Double Doors, to be covered with coarse woollen cloth, and accurately fitted.*

K. *Glass Guage, connected with the Pipe A, to indicate the depth of Water in the Reservoir at different times, and thereby to test the waste of Ice, as a Calorimeter in particular seasons*

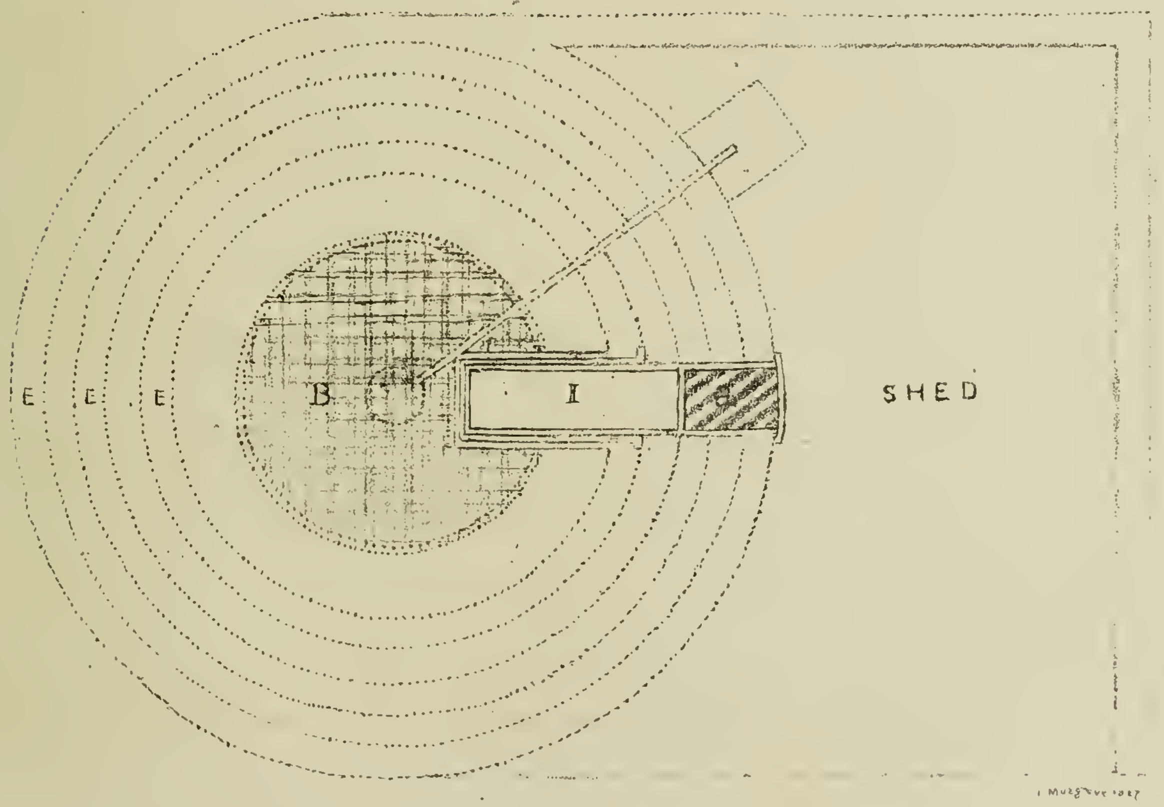
a. *Ice Drawer, moved by Iron rack work, and divided into compartments for preserving Meat, Fish, Game, Ice for daily use, &c. &c.*

It may be observed that the Drawer ought to run in a wooden case, highly saturated with Oil, Tallow, or Soft Soap, into an Air-tight Trunk of Lead, so that the articles contained may be exposed to the frigorific impressions of the Ice-House, without allowing, upon opening the Drawer, the merest ingress of Atmospheric Air The front of the Drawer, moreover, ought to be filled with powdered Charcoal or other bad conductor of heat, and here experiment may enable us to form a Cell for the preservation of Fruit, the point being to keep the same cool without incurring the danger of its becoming frosted; and it may further be observed, that by placing a Jar partially filled with sulphuric acid, or a few

ICE HOUSE



SECTION THROUGH THE ICE HOUSE



GROUND PLAN
OF THE
ICE HOUSE

0 5 10 20 feet

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pounds of quick Lime, or highly dried Oatmeal, or Garden Mould, &c &c. in one of the compartments, the atmosphere of the Drawer may not only be kept *cool or cold,* but philosophically *dry* at the same time.

From what has been said it will appear that a cheap or temporary Ice-House may readily be formed by surrounding a concave bottom of highly tempered Clay with a circular Brick Wall eight feet high or so, and then roofing in the entire structure by long poles resting upon the ground, and well thatched like an Indian Hut. The Russians and Americans in the present day find no difficulty in preserving Ice all Summer above ground, in very rude contrivances: and I would here take leave to say, that to establish a *productive* Ice-House in the porous Red Sand Stone of this district, the floor should be laid with Clay, and furnished with a Lead Pipe (leading to a Well) as above described, and that the side-walls moreover should be pointed and coated with Roman or other Cement to render them impervious to Vapour.

As so much has been said about the agency of "Aqueous Vapour," it may be proper, in further illustration of the subject, to observe that Water during its assumption of the elastic or Vaporous form absorbs heat, and that the quantity of Water contained in Vapour is in proportion to its temperature and the diminution of the pressure of the Atmosphere. Evaporation was long considered in the light of a Chemical solution of Water in Air, but Mr. Dalton has determined by experiment that the quantity and force of Vapour in a given volume of Air is precisely the same as in Toricellian vacuum at the same temperature. Thus at the temperature of 32° a cubic foot of Air contains, under mean Barometrical pressure, 2.539 grains of Water, at 48° 4.279, at 212° 207.218, thus supposing a pound of Water to find entrance under the modified form of Vapour, the quantity of Ice so melted may be calculated by multiplying by 7½ times the weight of Vapour admitted: hence the immense importance of rendering our Ice-Houses impervious to Vapour, "it being one of the most effectual carriers of heat that can be conceived, and will deposit it only on such bodies as are colder than itself." The condensation therefore of Vapour in an Ice-House, at the rate of only 60 grains in the minute, would be sufficient to thaw 12 tons of Ice annually.

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